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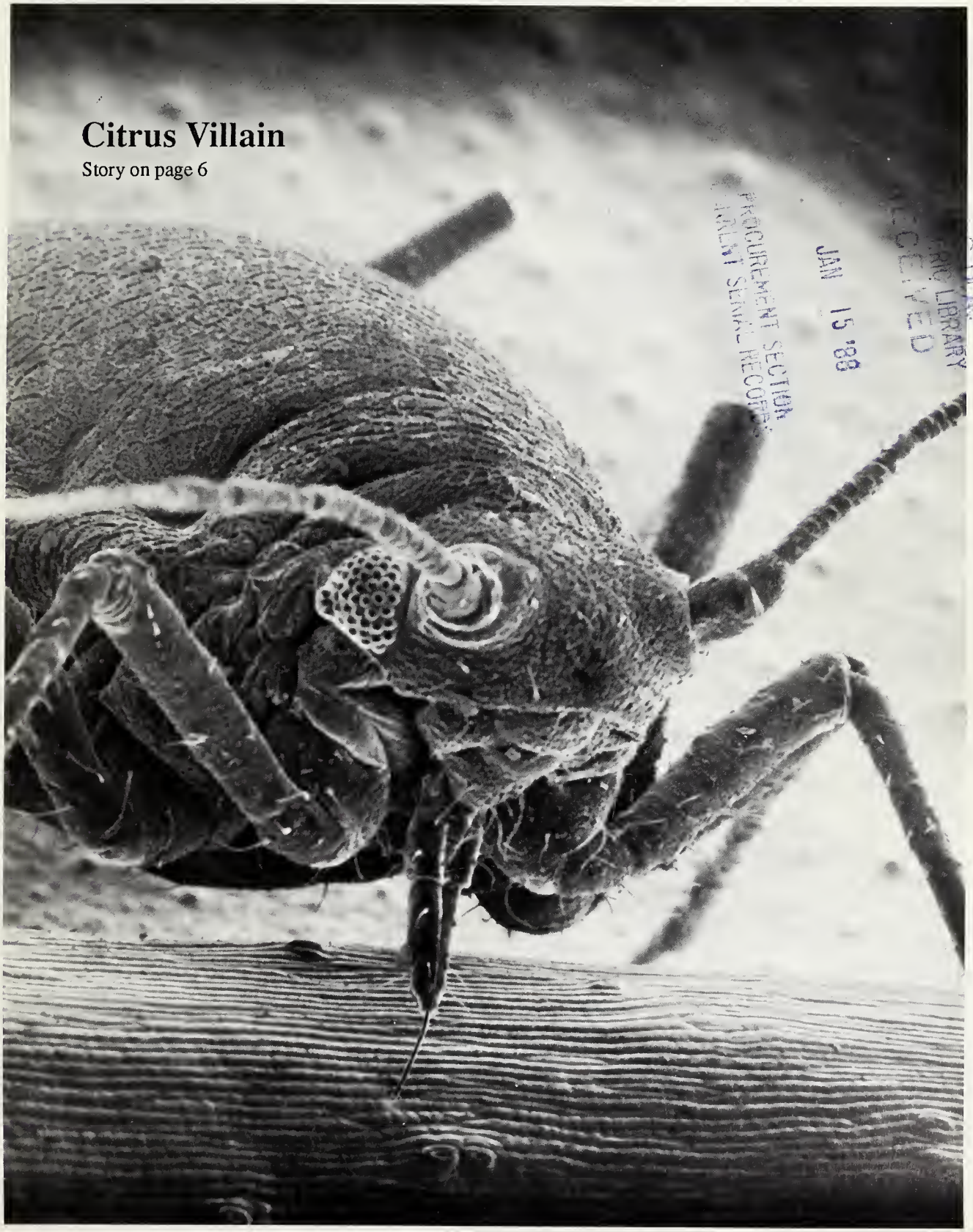


Citrus Villain

Story on page 6

The Beltsville Break-In

On August 23, 1987, the Band of Mercy, a group of animal rights activists, staged a midnight break-in on USDA's Agricultural Research Service property to dramatize their beliefs. They cut through a chainlink fence near restricted laboratories of the Animal Parasitology Institute at Agricultural Research Center in Beltsville, Maryland. Then they stole (or, to use their term, "liberated") a number of experimental animals—27 cats and 7 African miniature pigs. Some of the cats were infected with the parasite that causes the disease toxoplasmosis, which is contagious to cats and can cause spontaneous abortions in sheep and prenatal deformities in human children. After spray-painting slogans on a federally owned building, the trespassers escaped.

The people responsible for the theft are still at large. However, they have issued several statements to the news media through a spokesperson who told the public of the so-called "humane" objectives for their actions. A Band of Mercy member was quoted as characterizing the lab's work as "animal abuse with no clinical significance." Their judgment is uninformed. Jitender P. Dubey, the veterinarian whose work was interrupted, has made significant inroads into preventing *Toxoplasma* parasites in animals. He is responsible for discovering how the disease passes from cats to humans, a finding that would not have been possible without animal research. He also proved that the same parasite causes abortions in sheep.

Toxoplasmosis afflicts people as well as livestock. A fourth of AIDS patients die of this disease; it may also cause mental retardation and blindness in children, according to *U.S. Medicine*. So Dr. Dubey is entirely correct in stating that his research directly relates to human health.

This break-in and the apparent trend toward similar actions have raised a host of related concerns. Some of our scientists, particularly those who work with animal diseases, are concerned that stealing of laboratory specimens—possibly virulent—could lead to tragedy. While professional researchers, accustomed to following safety procedures to the letter, take negligible risk in handling laboratory animals, a layperson taking similar risks could suffer dire consequences. Fears like this have caused us to heighten security at our facilities.

Still, the need to hire more guards, buy more locks, and build more fences is troubling. It may well turn out that there's not enough chainlink in the world to keep trespassers out of research facilities if they are determined to gain access by breaking the law.

It is ironic that ARS does not bar visitors to our facilities; we welcome them. Every day we show people our research in progress, and, had they asked, we would have shown the unknown raiders of the Band of Mercy exactly what Dr. Dubey was doing and explained why.

Visitors will find that animals owned by ARS are well treated. They are cared for in accordance with guidelines devised by the U.S. National Institutes of Health. Each research location is required to appoint an Animal Care and Use Committee to oversee its animal program. We vigorously enforce regulations specifying how our lab animals must be cared for, and these standards are quite exacting.

So you can imagine my displeasure when, despite our energetic enforcement of these regulations, we nevertheless had useful work disrupted at the ARS Animal Parasitology Institute by lawbreakers. It goes without saying that the loss of our animals represents a frustration for the researcher and an unnecessary expense to the taxpayer.

The only people whom I've heard express support for this theft and vandalism were already convinced that this kind of action is justified.

Since, however, there are people who sincerely question whether laboratory animals should be used to advance the course of science, I think some rational dialog is in order. It seems reasonable to search for answers and to share our reasoning processes with the public.

In the past century, science has made enormous strides against the age-old fears of disease and hunger. Who would question, for example, the exchange of the lives of laboratory animals to prevent the crippling by polio? Of course, the research team of Dr. Jonas Salk had to perform extensive testing on lab animals before the polio vaccine was perfected. Similar use of lab animals has led to the development of insulin, new inroads against cancer, and perfection of most surgical techniques. It has also led to most improvements in veterinary medicine.

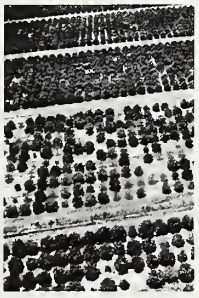
This does not and should not imply wanton waste of animals. In some cases, scientists have been able to redesign their experiments so that laboratory animals are no longer needed. More and more, they are using computer simulations of animal processes. Our newly acquired magnetic resonance technology offers a way to observe life processes inside a specimen while sparing the animal's life. Whenever it is scientifically valid to avoid the use of lab animals, we do so.

In situations where the use of laboratory animals is our only scientifically valid option, we think the importance of our objective warrants their use. It is my conviction that human needs have a higher value than those of laboratory animals, whether we're trying to rid the world of dangerous parasitic diseases, learning more about the mechanisms of infant nutrition, devising a vaccine to combat foot-and-mouth disease, or improving the world's livestock.

Terry B. Kinney, Jr.
Administrator, Agricultural Research Service

Agricultural Research

Cover: A melon aphid, *Aphis gossypii,* about the size of a grain of salt, spreads the deadly citrus virus, tristeza, as it feeds on citrus leaves. Tristeza kills from 200,000 to 500,000 trees a year in Florida. ARS scientists are on the trail of remedies for this and other citrus problems. Scanning electron micrograph by Norita Chaney catches this aphid feeding through its stilet inserted in an orange leaf. Magnified about 300 times in cover photo. (PN-7267)



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Terry B. Kinney, Jr., Administrator
Agricultural Research Service

New Test Helps Guard Against Food Poisoning

A purple dye that lets scientists distinguish between harmless and virulent strains of a bacterium may lead to a new way of detecting organisms that cause food poisoning, an Agricultural Research Service scientist says.

Saumya Bhaduri, an ARS microbiologist at Philadelphia, has found that crystal violet dye binds to disease-causing strains of the bacterium *Yersinia enterocolitica* but does not affect the harmless strains.

"Our new test will make it easier for industry and regulatory agencies to safeguard food by pinpointing the strains that are virulent," Bhaduri says. "It is simpler, quicker and more reliable than current tests, which are often inconclusive and can take days to complete."

The purple dye works by binding to an unidentified substance produced in *Y. enterocolitica* strains containing a plasmid—genetic material outside the cell chromosome—that causes a strain to be virulent.

The new test—which takes 3 to 5 minutes—also gives scientists a way to study whether heating, salt, acidity, radiation, or other treatments will eliminate the plasmid in virulent strains.

Y. enterocolitica is emerging as a food pathogen of concern to the Food and Drug Administration and the Centers for Disease Control (CDC). It can reach infectious levels in 4 days in mishandled milk, beef, and other meat products and grows at temperatures as low as 32°F, Bhaduri says. Most strains are harmless, but the few strains that are virulent cause classic food poisoning symptoms—abdominal pain, diarrhea, and vomiting.

According to CDC, there have been several reports of food poisoning from *Y. enterocolitica* in recent years. The last reported outbreaks were in 1982—16 cases in Pennsylvania from tainted bean sprouts and 172 cases linked to contaminated milk in Arkansas, Tennessee, and Mississippi.

Bhaduri says once people eat food contaminated with the organism, it grows in the intestines and produces toxic substances that scientists have yet to identify. These may be what actually cause sickness, but scientists aren't certain.

Through ARS,he has applied for a patent on the test. His findings were reported in the June 1987 issue of the Journal of Clinical Microbiology.—By **Sean Adams,** ARS.

Saumya Bhaduri is in USDA-ARS Microbial Food Safety Research, Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, PA 19118. ♦

Which Little Piggy Stays Home?

Deciding which little piggy goes to market and which one stays home—to raise another litter—is simpler today for U.S. hog breeders with a new computer program available to their associations, says a USDA Agricultural Research Service scientist.

The program is called STAGES, for Swine Testing and Genetic Evaluation System. It predicts the dollar value of specific genetic traits, such as backfat thickness and body weight, says Dewey L. Harris, an ARS animal geneticist in Clay Center, Nebraska. "STAGES takes the pencil work out of breeding strategy, which uses complicated mathematical formulas," he says.

Designed for breeders of purebred hogs and for breeding stock customers, the program is now available only through the eight U.S. breed associations. In the future, breeders with on-the-farm computers could access the program by phone and get a printout in minutes.

The computer program predicts the performance of progeny of specific hogs, he explains. It combines traditional information— pedigree records—with new information on animal performance.

STAGES was developed by Harris and researchers at Purdue University, with support from the National Association of Swine Records and the National Pork Producers Council. The beef, dairy, and poultry industries use similar programs, and "purebred hog breeders should jump on the bandwagon by adopting this one," says Harris.

The new program has already processed records of 12,000 hogs from 33 breeders and could process well over 100,000 per year. Five breed associations are using the system fully, and the other three are gearing up. All have access to computers to process and analyze data and rank animals throughout the country by their production efficiency.

Harris says STAGES can predict many characteristics important to commercial producers. These include ratio of feed used to pounds of gain, litter size, litter weight weaned per sow, growth rate, backfat thickness, and weaning and growth data for an entire herd, including individual animals and their parents within the herd.

A printout of the information, plus a performance pedigree certificate for each animal, is valuable to the breeder or producer who wants to buy or sell boars or gilts, as well as to the breeder looking for improved stock, he says.

Now, the seedstock breeder sends data to the association by mail or over the phone, and the association sends a performance pedigree certificate to the member subscriber within 24 hours after the data are received. The service cost is set by each association.—By **Linda Cooke**, ARS.

Dewey L. Harris is at the USDA-ARS U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, NE 68933. ♦

White Lupin: Future Grain for the North?

While tourists flock to northern Maine every summer for the pleasant weather, most grain legumes find the season too short to grow well, leaving local farmers out in the cold when it comes to raising high protein feed.

But the Agricultural Research Service is coming to their aid with white lupin, a 33-40 percent protein grain legume originally from the Middle East that is relatively cheap to produce. It can be used for fodder or to produce a grain crop.

White lupin *(Lupinus albus)* is new to Maine, where its growing season includes the cool weather of spring and fall. It produces less harmful alkaloids than other white lupins grown as winter annuals in the southeastern United States.

White lupin is also of interest for its potential to change the local crop rotation from 2 to 3 years, alternating with potatoes and oats. "A longer rotation would cut down on soil erosion and, because it's a legume, it would increase a field's fertility by fixing nitrogen into the soil," says William M. Clapham, a plant physiologist working at ARS' New England Plant, Soil, and Water Laboratory in Orono, Maine. "White lupin follows potatoes well because the fields are left with a potassium-to-phosphorous balance that favors legumes, and white lupin prefers more acid soils than other legumes."

Growers are looking at the possibility of more than just a local forage crop to serve sheep and dairy farmers. They see the opportunity for a white lupin seed industry because when perfected, this crop will be so useful in all the northern states, or anywhere with a short, or cool, growing season. "As a locally grown source of protein for feed, white lupin could substantially improve the rural economy," Clapham says.

In 1981, the Maine broiler industry crashed because the price of bringing in soybeans went up and there was no local source of protein to replace them. "White lupin could prevent something like that from happening again," he says.

White lupin still has a few unsolved management problems. Since the plant thrives in cool weather, it tends to remain green very late in the harvesting season. If it is not exposed to a cold snap at just the right time, lupin will develop lateral branches that don't ripen at the same time as the main stem.

Clapham is eagerly awaiting test results of several methods of handling the lateral ripening problem that were tried during the past growing season: manipulating the plant density, planting date, applications of a commercially available growth regulator; removal of lateral stems; and cutting the main stem, leaving the lateral branches to ripen.

The forage is a poor competitor against local weeds like wild mustard, Clapham says. "But we're looking at the effects of applying herbicides at different times during the season to develop a management strategy."

A few New England farmers aren't waiting for perfection. They're already growing the legume, increasing acreage in white lupin from 10 acres 3 years ago to 500 last year.—By **Kim Kaplan,** ARS. ♦

William M. Clapham is at the USDA-ARS New England Plant, Soil, and Water Laboratory, University of Maine, Orono, ME 04469.

Fiber Component May Bring Down Colon Cancer Risk

If a high-fiber diet reduces the risk of colon cancer, as some evidence suggests, a U.S. Department of Agriculture scientist believes he has found one of the components responsible.

"It is the same component that gives fiber much of its cholesterol-lowering property," says chemist Peter D. Hoagland of USDA's Agricultural Research Service.

Calcium pectate, a structural component of plant cell walls, binds to free-floating fatty acids in a test tube, and presumably the same process takes place in the human body. The two molecules form a salt bridge, with calcium acting as the span, Hoagland says.

Presumably, the binding reduces the concentration of free fatty acids in the colon, keeping them "out of circulation," he says. Canadian studies suggest that free saturated fatty acids may promote formation of tumors in the colon.

Population studies and experiments with laboratory animals have linked colon cancer to high-fat diets, but the evidence so far is inconclusive, cautions Gerald F. Combs, ARS' national program leader on human nutrition.

In fact, highly controlled studies show that animals on a high-fat diet eat more than those on a normal diet, and that the extra calories, not the fat itself, appear to accelerate tumor growth.

Hoagland and colleague Philip E. Pfeffer, who work at the ARS Eastern Regional Research Center in Philadelphia, Pennsylvania, had reported earlier that the same type of binding occurs between calcium pectate and bile acids, accounting for the ability of certain types of fiber to lower serum cholesterol. The body normally reuses bile acids again and again to help digest dietary fats. But if they're bound to fiber components, the body has to dip into its cholesterol supply to synthesize more.

So far the scientists have observed bile acids binding to fiber from carrots, cabbage, onions, and most recently, broccoli, but they suspect it is widespread among fruits and vegetables. "When we remove the calcium pectate," says Hoagland, "a lot of that binding disappears."

"It boils down to a balanced diet. If you eat a fair portion of fresh fruits and vegetables, you'll be that much healthier."—By **Judy McBride,** ARS.

Peter D. Hoagland and Philip E. Pfeffer are at the USDA-ARS Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, PA 19118. ♦

Orlando Lab Puts Fresh Squeeze on Florida Citrus Problems

Life in Florida may be fun for retirees at Miami Beach, tourists at Disney World, or space buffs at the Kennedy Space Center, but the Sunshine State has been perilous lately for a resident that first arrived about a half century after Ponce de Leon looked for the Fountain of Youth.

This resident is, of course, citrus, originally cultivated in China in the 12th century and first established in Florida at Saint Augustine in 1579.

Florida's weather hasn't been kind to the citrus tree. Record freezes in 1981, 1983 and 1985 virtually wiped out production in Florida's northern growing areas. Citrus trees grow throughout

Record-breaking freezes cut Florida' s orange production in half in the early 1980's.

most of the year and don't protect themselves by becoming dormant in the winter. So freezing temperatures kill the tree by turning to ice the water that flows through its veins.

Freezes wiped out 400,000 acres of trees between 1980 and 1986. The net loss, taking into account new plantings, was about 220,000 acres. The most dramatic drop was in orange production, which fell from a peak of 207 million boxes in 1979-80 to a low of 104 million in 1984-85, according to the Florida Department of Citrus.

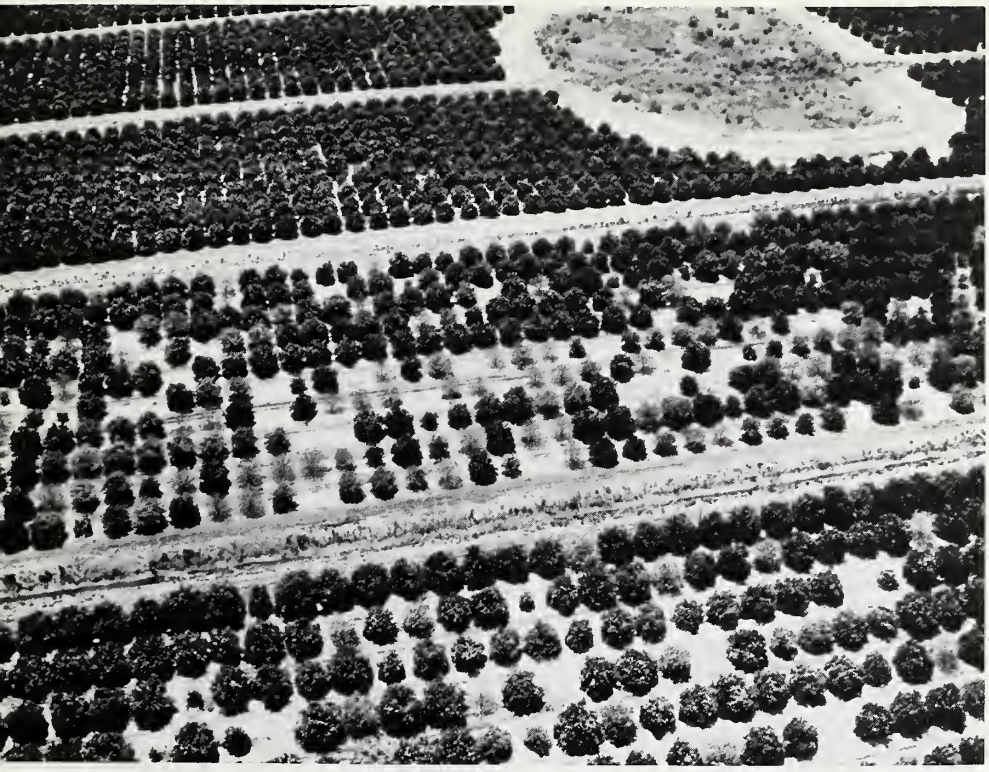
Florida's once dominant orange juice industry produced 1.2 billion gallons of juice in 1979-80, 94 percent of the country's total. By 1986-87, juice production had been cut by 467 million gallons, or 39 percent. Today the state supplies a little over half the U.S. market, as less expensive imported juice from Brazil and other countries filled the production void created by the freezes.

The industry is recovering, and production has been increasing since the last major freeze. The 1987-88 orange crop is projected at 130 million boxes.

There's obviously a market for a cold-hardy citrus tree, but that is probably years away, says George

BARRY FITZGERALD

Inside a cold chamber, plant physiologist George Yelenosky attaches a temperature sensor to an orange blossom. The study will determine at what temperature plant tissue freezes in relation to surrounding air temperatures. Understanding this relationship may lead to citrus varieties that are more cold tolerant. (0487X300-8)



STEVE GARNSEY

Missing and withered orange trees in foreground provide a dramatic example of what happens when tristeza virus invades a citrus grove. These trees are growing on a sour orange rootstock that does not tolerate the virus while healthy trees in the more distant groves are grafted to a tristeza-tolerant rootstock. (PN-7264)

Yelenosky, who heads the Stress and Bioregulation Research group at the U.S. Horticultural Research Laboratory run by USDA's Agricultural Research Service.

Temperatures just below 30°F will cause freezing injury in citrus. As a general rule, he says, trees that are growing in warm temperatures above 50°F are more susceptible to damage from a sudden drop in temperature. When the temperature drops to the 40's or upper 30's, trees go into a quiescent state and are more protected from freezing temperatures.

Over the past several years, Yelenosky has been studying protein changes that occur inside the tree when it is exposed to cold. For example, one protein found in the trifoliate orange may help to give this tree its cold hardiness. The trifoliate orange, a citrus relative that grows as far north as New Jersey, is a key in breeding because of its cold tolerance. Eventually, Yelenosky wants to map out this and other citrus proteins that help give resistance to cold.

"If we can do that, then we have the potential to work toward genetic engineering to transfer these cold-hardiness genes into commercial varieties," Yelenosky says. "This is years away, but if we can develop a tree that has 2°F to 3°F more cold tolerance it would be a big help."

The lab recently hired a plant geneticist, Randall Niedz, to work on genetic engineering and other biotechnology techniques in citrus breeding.

Even if cold hardiness can be bred into trees, scientists say there are other serious troubles ahead for the citrus industry:

• Tristeza, a viral disease that threatens some 20-25 million citrus trees growing on susceptible rootstock. Spread by aphids, tristeza kills the tree by blocking nutrients from flowing between the roots and leaves.

• Canker and citrus bacterial spot, diseases that cause blemishes on leaves and fruit. About 20 million nursery plants and 5,000 mature trees have been destroyed over the last few years to eradicate these diseases.

• Harmful nematodes that feed on the roots and eventually damage them, reducing the tree's productivity. Chemicals used to control nematodes are seeping through Florida's sandy soil, threatening groundwater, wildlife, and natural resources.

• Blight, which causes the leaves to wilt and stems to die and eventually kills the tree. It is particularly devastating because symptoms don't appear until the tree is at least 6 years old, when it begins to be commercially productive. Scientists aren't yet certain what causes citrus blight.

"The citrus industry here is on the way back," says Richard T. Mayer, director of the Orlando-based research lab. "But how well citrus does in the coming years depends to a large degree on how well we can work with industry and Florida state researchers to deal with these problems."

While freezes have been a problem in recent years, tristeza virus may be the most serious citrus threat of the future. Plant pathologist Stephen M. Garnsey estimates about a third of Florida's 60 million citrus trees—valued at over $2 billion—are susceptible to tristeza, a disease originally from Asia and first reported in Florida in 1950.

The trees that are vulnerable include all sweet oranges, grapefruit, and mandarins grown on a popular sour orange rootstock. (Citrus fruit trees are normally grafted to the roots of other more hardy trees such as the sour orange, rough lemon, or trifoliate orange.)

Tristeza virus is carried by tiny insects, aphids, which feed on citrus leaves and in so doing infect the tree, according to ARS entomologist Raymond K. Yokomi. The disease then spreads to the rootstock, interfering with the flow of nutrients.

Tristeza-infected trees can die a few weeks after symptoms first appear, and the disease is estimated to kill between 200,000 and 500,000 trees a year in Florida. "It's so widespread here that it's not practical to eradicate it," Garnsey says. "There are rootstocks resistant

to tristeza but not to canker, blight, cold, and other problems. It's not a real easy situation for a grower."

A possible solution now being tested is to infect trees with a mild strain of tristeza virus to prevent severe strains from taking hold. This approach, called cross protection, is similar to vaccinating humans or domestic animals and livestock.

At Beltsville, Maryland, Garnsey and other scientists are studying different tristeza strains from around the world, including several mild strains from South America, Israel, and Japan for use in greenhouse tests of cross protection. Results should be in by mid-year,

Cross protection—similar to vaccinating animals—is being tested on citrus trees to prevent them from getting devasting strains of tristeza.

Garnsey says. Other field tests are in progress in Florida.

Although tristeza may be a sleeping giant of sorts, citrus canker has been the attention-getter lately, primarily because of canker outbreaks in 1984 and 1985 that prompted a major eradication effort. This bacterial disease causes lesions, or scars, on the leaves and fruit peel, says ARS plant pathologist Timothy R. Gottwald.

"These lesions interfere with fresh market sales and exports to canker-free states and countries," he says.

Gottwald is studying two different types of canker, the Asian and Florida strains, and is comparing the differences in how they spread, how severe they are, and other factors. His research often takes him to Argentina as well as the ARS facility in Beltsville because the state of Florida has only recently allowed field studies of the Florida, or nursery, strain inside the state. The Asian strain is banned from the state.

Identifying and comparing the canker strains more easily and accurately is now possible with a genetic fingerprinting technique. Beltsville plant pathologist John S. Hartung says each bacterial strain has its own genetic fingerprint, a series of DNA bands that allow him to tell one strain from another. DNA is the genetic material inside the bacterium.

"So far we've found that Asian strains from around the world tend to have similar fingerprints, while the Florida strains are different from each other and from the Asian types," Hartung says. "It appears that the Florida strains are native and not closely related to the Asian strains."

Hartung says scientists will soon be referring to the Florida nursery canker as citrus bacterial spot, which causes symptoms similar to those of canker. Spot and canker are caused by different strains of the same bacterium, *Xanthamonas campestris* pathovar *citri.*

Like canker, spot, and tristeza, nematodes pose production problems. But nematode control is related to one of the citrus industry's biggest environmental headaches, says David T. Kaplan, head of the lab's Subtropical Plant Pathology Research unit.

Nematodes live in the soil and attack citrus roots, weakening the tree and making it commercially unproductive. For years, growers controlled nematodes by treating the soil with nematicides. To control the burrowing nematode *(Radopholus citrophilus),* the state began a program to establish barriers around citrus orchards. These 25- to 40-foot-wide strips of fallow land were fumigated to prevent the burrowing nematode from moving from infested to clean trees nearby. About 600 miles of barriers were established, and Kaplan says nematicides were sometimes applied at concentrations of up to 50 gallons an acre per year. As of 1985, about one-third of the state's groves were being treated with nematicides.

But the chemicals began to show up in wells and in groundwater. For example, ethylene dibromide (EDB), now banned as a nematicide in Florida, has been found in about 2,000 out of 20,000 wells tested since 1983, and about three-fourths of the contaminated wells were in citrus areas, according to the state's Health Department. Besides banning EDB, the U.S. Environmental Protection Agency restricts another nematicide, aldicarb, now used to control the citrus nematode *(Tylenchulus semipenetrans).* Aldicarb may be applied only during Florida's dry season.

"It's clear that we need new ways to control nematodes that don't damage the environment," Kaplan says.

There are nematode-resistant rootstocks available, he says, but "we don't have one rootstock that withstands the major diseases with the key horticultural characteristics, such as high fruit quality, that growers need."

Research on the burrowing nematode had been limited because there was no reliable method for raising large numbers for study. But this year Kaplan overcame this problem. He says, "We can produce more than 3 million a week,

TIM McCABE

TIM McCABE

compared to only 5,000 when we began."

Of all the citrus problems, few are as mysterious as blight, which USDA scientists began studying in the 1890's. It is also known as roadside decline, because it seemed to affect trees along highways.

Poorer soil conditions along roadways—caused by limestone roadbeds leaching into citrus fields and other factors—may account for the "roadside decline," says Stanley Nemec, a plant pathologist who also studies blight.

Horticulturist Heinz Wutscher agrees that soil nutrition may be an underlying factor that contributes to blight. He's found that lower levels of minor elements and high calcium levels in deep-tilled areas were associated with losses of Hamlin orange trees on rough lemon rootstock, which is susceptible to blight.

Conventional Breeding Fills the Gap

Although genetic engineering may be years away, conventional breeding is producing better varieties today. In 1987, the lab released five new scion varieties, according to C. Jack Hearn, who heads the Horticulture Breeding Research group.

Three were oranges—Sunstar, Midsweet, and Gardner. Hearn says they will help the orange juice industry because they ripen from mid-January through March, in the middle of the growing season. This is important because the freezes killed many of the midseason orange trees. Also, Hearn says the three oranges produce juice with better color than the early-season oranges.

The other two new releases were Fallglo, an early ripening mandarin, and Flame grapefruit, whose dark red color is popular with consumers. Hearn says Fallglo is sweet, ripens early, from mid-October to Thanksgiving, and is ideal for the fresh market. Flame grapefruit is more resistant to herbicides, root rot, and cold than the other dark red grapefruit now grown in Florida.

These varieties won't be producing fruit commercially for several years, but a mandarin called Sunburst, released in 1979, is now grown commercially on at least 500-600 acres in the state.

Sunburst is considered a tangerine for marketing purposes. Hearn says, "We expect it to replace the standard tangerine because it ripens earlier, has larger fruit, and resists disease better. One grower told me he thinks it will revolutionize the citrus industry in Florida."

The lab also released a popular rootstock, Swingle, in the 1970's. A cross between grapefruit and trifoliate orange, Swingle seemed to have everything—it's resistant to diseases, nematodes, root rot, and blight; is adapted to a wide range of soils, and has cold hardiness, good yields, and high-quality fruit.

Swingle seemed perfect until several years ago, when it was found to be susceptible to Florida nursery canker, or what scientists are now calling spot. Thousands of nursery plants were burned, and growers became hesitant to plant it, Hearn says.

"Growers are coming back to it because of all its positive qualities, but it shows you how difficult it is to find the ideal rootstock," Hearn says. "Even with its canker problems, Swingle's about the best available."

Plant geneticist Don Hutchinson, who breeds rootstocks, says breeders are producing rootstock crosses between citrus and the trifoliate orange. This citrus relative, originally from China, is dormant in winter and loses its leaves

TIM McCABE

Above: Plant pathologist Tim Gottwald tracks citrus bacterial spot (Florida nursery canker) through a two-and-a-half-acre grove of orange and grapefruit trees at Lost Hammock Nursery, Ocoee, Florida. Locations within the grove that are infected are plotted on the computer screen for easy reference. (PN-7268)

Left, above: Technician Carmen Henderson and plant pathologist Steve Garnsey measure the growth of infected orange trees to determine the severity of different tristeza strains. Tree at right is same age and variety as the stunted one Garnsey is holding, but infected with a mild strain of tristeza. (1187X1249-24)

Left, below: At the ARS citrus research area in Beltsville, Maryland, plant pathologist Edwin Civerolo examines lesions on the leaves of a hybrid citrus rootstock caused by one of the 120 strains of canker bacteria under study. (1087X1172-32)

like apple trees do, and Hutchinson's crosses have these characteristics.

"A resistant rootstock would help because then you wouldn't have to worry about the tristeza spreading from scion to the rootstock," he says.

The trifoliate orange has a major drawback, however, according to plant geneticist Herb Barrett. The fruit is acidic, inedible, and oily. "We have to get trifoliate orange's cold hardiness without its poor fruit quality," Barrett says.

Cold Treatment: Good and Bad Results

Fruit can also be damaged if it is chilled too rapidly after being harvested. Horticulturist Roy McDonald and chemist Harold Nordby are investigating why citrus fruit is damaged during rapid chilling down to temperatures in the 30's and 40's.

McDonald focused on putrescine, a chemical found in citrus skin. In laboratory studies, he found that putrescine greatly increases as chilling damages fruit. Putrescine increased 39 percent in grapefruit at 40° and 68 percent in lemons at 34°, McDonald says.

"These findings are preliminary but may help us learn more about the causes of chilling injury," he says.

Conditioning fruit to cold has also helped the Florida citrus industry ship its grapefruit to Japan. Thurman T. Hatton, Jr., who heads the Export and Quality Research group, M.A. Ismail, with the Florida Department of Citrus, and other cooperators found that by conditioning the grapefruit at 60°F for 7 days, it could be safely cooled to 34°F for at least 21 days during shipment to Japan.

"If you take a grapefruit off the tree in 90° heat and cool it down to the 40s right away, the peel will be pitted or turn brown," Hatton says. "But if you gradually lower the temperature in stages, you don't damage the fruit."

This cold-treatment technique has become especially important because it kills fruit fly larvae without damaging the fruit. EDB, banned as a nematicide, is also being phased out as a citrus fumigant after the 1988-89 shipping season. EDB has long been used to kill fruit fly larvae inside grapefruit. Japan, an important potential market, won't accept Florida grapefruit unless the fruit flies have been controlled or unless the fruit is grown in fly-free areas.

Florida shipped $50-$60 million worth of grapefruit to Japan in 1986. Of that, about $18 million worth was treated with the cold technique developed by ARS and Florida state researchers, says Richard Kinney, executive vice president of the Florida Citrus Packers Association in Lakeland.

When EDB is phased out, Kinney estimates that about half the Florida grapefruit shipped to Japan will be cold-treated. The rest will come from fly-free areas or will be controlled in another way.

"If we hadn't had cold treatment, we wouldn't have gotten that product to Japan," Kinney says. "This research has helped us maintain a very important market."—By **Sean Adams**, ARS.

All of the scientists in this article are based at the USDA- ARS U.S. Horticultural Research Laboratory, 2120 Camden Rd., Orlando, FL 32803, except Edwin L. Civerolo and John S. Hartung are with the USDA-ARS Fruit Laboratory, Bldg. 004, Beltsville Agricultural Research Center-West, Beltsville, MD 20705. ♦

New Products, Better Flavor Are Goals

Besides the work of the U.S. Horticultural Research Laboratory featured in the article at left, USDA's Agricultural Research Service conducts citrus research at the following locations. Most locations work in cooperation with scientists from state experiment stations and universities and often with other countries.

• USDA-ARS Horticultural Crops Research Laboratory, Fresno, California. Scientists are working on fumigation and chilling techniques for citrus that don't damage fruit yet guarantee that it is free from pests such as the Fuller rose beetle. Quality Maintenance, Genetics, and Transportation unit, research leader Charles F. Forney.

• USDA-ARS Fruit and Vegetable Chemistry Laboratory, Pasadena, California. Researchers are studying the "cloud" of fine particles in fresh citrus juice that provides the taste and texture. Other studies are also aimed at improving the quality of citrus fruit and juice products. Research leader, Vincent P. Maier.

• National Citrus Clonal Germplasm Repository, Riverside, California. This new facility is being established to collect and maintain citrus and date plant material and to make it available to breeders and researchers. Curator, Timothy E. Williams.

• U.S. Citrus and Subtropical Products Laboratory, Winter Haven, Florida. Scientists here are developing new and improved products from citrus and other subtropical fruits and vegetables. These products include juices, concentrates, fruit sections, canned products, and lightly processed products suitable for salad bars. Laboratory director Robert E. Berry.

• USDA-ARS Fruit Laboratory, Beltsville Agricultural Research Center, Beltsville, Maryland. About 250 strains of foreign citrus pathogens from around the world have been brought together here as part of a study to protect U.S. citrus from the diseases they cause. Well outside of the normal citrus growing areas, the Fruit lab's 3,000 trees in permanent and temporary greenhouses can be infected with tristeza, canker, or citrus-greening bacteria without possible spread to commercial orchards. Research leader, Edwin L. Civerolo.

• USDA-ARS Subtropical Agricultural Research Laboratory, Weslaco, Texas. Scientists are investigating alternatives to ethylene dibromide for controlling Mexican fruit fly larvae in grapefruit. Laboratory director William G. Hart.—**R.W.**

Menthol Clears Bee's Breathing Tubes

Cough drops for bees?

Not exactly. But the same menthol that soothes sore throats does help honey bees breathe more freely if they're infested with tracheal mites.

According to William T. Wilson, an ARS entomologist in Weslaco, Texas, menthol vapor, if given over a 3-week period in the hive, will kill tracheal mites without harming the bees.

"In our tests, mites started dying within a few hours after we put menthol crystals in the hive. In 3 days, half were gone, and then after 3 weeks, bees were mite-free," says Wilson, who heads up a team to study the bee mite problem.

"Menthol doesn't hurt honey bees but does irritate them enough to make them fan their wings." He adds, "Of course, this is what we want, because fanning spreads menthol around the hive."

The treatment procedure would be relatively simple, Wilson says. To kill mites, beekeepers would put a screen packet (about the size of a standard envelope) filled with menthol crystals in each hive. Cost per hive is estimated at 50 cents to a dollar—a "reasonable amount" to a beekeeper, Wilson says.

Before menthol can be used for this purpose, Wilson cautions, it would have to be approved by the U.S. Environmental Protection Agency. Although, menthol is already in products such as cough drops, applying it as a pesticide requires registration for a new use.

This is how the tracheal mite, *Acarapis woodi,* does its dirty work: it parasitizes—actually lives, feeds, and reproduces in—a bee's breathing tubes. It blocks oxygen flow, robbing flight muscles of the oxygen needed for bees to fly. Each honey bee's lifespan is also decreased about 30 percent, which means fewer bees at any given moment to make honey. This plus the fact that they're generally weaker fliers "makes for an unproductive hive," Wilson says.

In fact, studies done in Mexico (where the mite is well established) by a University of Georgia scientist showed that heavily infested colonies produced only one-eighth as much honey as did healthy colonies. Losses like these could threaten the $150-million-a-year honey industry here in the United States.

First detected in 1984 in Texas, the mite has since been found in 31 states.

TIM McCABE

The ARS Honey Bee Research unit, which Wilson leads, was set up in October 1985, to work on the problem.

Currently, the only way to completely control the spread of tracheal mites is to destroy infested hives—a costly practice. Several states have eradicated this miniature pest but face a continuing threat of reinfestation.

Much of the field work in the menthol study was done in Mexico where honey bees are already heavily infested. ARS scientists worked in cooperation with researchers at the Mexican Agricultural Research Station at Rio Bravo and with individual property owners.

Wilson says, "We keep our research hives on farms, and we also collect swarms in people's backyards. As a token of our appreciation for watching the hives, we give them whatever honey the bees make."

This winter they are working with state officials and beekeepers in Nebraska to see if menthol affects overwintering bees.—**Jessica Morrison,** ARS.

William T. Wilson is in USDA-ARS Honey Bee Research, Subtropical Agricultural Research Laboratory, P.O. Box 267, Weslaco, TX 78596. ♦

WILLIAM WILSON

Top: Entomologist William Wilson and an assistant inspect honey bee hives near Weslaco, Texas, for mite infestation. (0387X158-4)

Above: Microscopic view of eggs and immature mites blocking the breathing tube of a honey bee. (0687X610-11A)

Planned Parenthood for More Perfect Potatoes

Don't pity the humble potato; it's actually a finely tailored product of research. Highly nutritious, inexpensive, available fresh year round, and processed into dozens of products, the potato is the nation's number two food crop. Yet few people realize that it reaches their tables only after intense scientific, agricultural, and market scrutiny.

Potato scientists, farmers, potato processors, supermarket chains, and in the East, the Maine Potato Seed Board all chip in to make the more perfect potato. They participate in a unique partnership coordinated by USDA's Agricultural Research Service known as the USDA Eastern Potato Germplasm Evaluation and Varietal Improvement Program.

"We've barely touched on the genes available for potato breeding. There are more than 5,000 varieties known, but only 6 make up 80 percent of the U.S. crop."

Raymon E. Webb, Agricultural Research Service

Led since 1971 by ARS potato breeder Raymon E. Webb, the program has produced 12 new varieties. These have brought new income and reduced expenses to farmers, expanded markets, and made better potato products.

Nationally, farmers receive nearly $2 billion each year for their harvest, enough potatoes to feed an average of 125 pounds to every person in the United States. The potato-processing industry turns 15 billion pounds of raw tubers into at least 25 major food products, which include nearly half of all salted snack foods consumed.

Potatoes are grown commercially in 38 states. The improvement program develops spuds that chip, french fry, or bake better, resist local or regional potato diseases, and mature at the right time for states of different latitudes.

A good example is Atlantic variety introduced in 1976. Atlantic can be made into potato chips with 10 percent less fat because the potatoes have more solid tissue and less liquid. During cooking, they take up less frying fat. The desire for lower-fat chips has made Atlantic the nation's number three chipping potato, "a fast rise in an industry where growers and processors tend to stick with varieties that have put money in the bank in the past," says Webb.

In Florida, where growers already have a marketing edge because they harvest months earlier than northern farmers, Atlantic is a big hit. Over 20 percent of the nation's spring potato harvest is grown there. Chips for July 4th cookouts are likely to come from Florida-grown potatoes, says Webb.

Farmer Tom Houghton was the first to bring Atlantic to Florida. Houghton and his sons in Fort Fairfield, Maine, grow seed potatoes—disease-free tubers that just prior to planting are cut into pieces that sprout into new plants. He took 25 bags of Atlantic "seed" to Florida to try in 1979. Now, over 80 percent of northern Florida production is Atlantic.

"For several years until the market adjusted and everybody started growing it, we got a 20-percent higher price for Atlantic than a previous variety," says Houghton. Florida yields are up 14 percent in the past 10 years, an increase due mostly to Atlantic, according to Florida state breeder James Schumaker.

Another breeding success is BelRus, the first good russet potato (coarse brown-skins) for eastern farms. It does not form knobby shapes from the East's erratic rainfall, as other russets do. BelRus allows eastern growers to compete with another popular russet, the Russet-Burbank, which is grown largely in western states in irrigated fields but does poorly in the East.

For farmer Joseph Jackewicz, Sr., of Magnolia, Delaware, BelRus fills a market niche in July when russets from the west are in limited supply. Seven years ago, he tried 25 acres of BelRus. Now he's up to 250 acres, supplying various grocery chains from Boston to Philadelphia.

GEORGE ROBINSON

At an ARS farm in Aroostook County, Maine, Raymon Webb (left), farm manager Dave Wilson (center), and James Schumaker inspect the newest potato clones. (1087X1065-7A)

"To most people, a potato is a potato," says Webb. "But whether we pursue the perfect baker for a gourmet restaurant, 6-inch-long French fries, or a lower fat potato chip, consumer acceptance is achieved by complex evaluation."

Before growers even see them, experimental potatoes are tested by the thousands for 8 to 10 years by Webb and cooperating scientists from 20 eastern states. Webb's ARS colleague Joseph J. Pavek in Aberdeen, Idaho, runs a similar program for western states.

Complicating the process are both human and botanical demands. First, there is a galaxy of consumer- and market-driven requirements to meet: high yield, potato size and shape, inside color and taste, skin appearance, storability, baking quality, frying quality, chipping quality, vine vigor, drought tolerance, resistances to over 50 pests and diseases, and dozens of lesser traits.

Botanically, potatoes are stubborn plants to breed. They have 48 chromosomes, a large number that translates into progeny of many different genetic

TIM McCABE

Plant pathologist Raymon Webb (left) and geneticist Kathy Haynes discuss the characteristics of the first seedling potato tubers developed by crossbreeding specific potato hybrids. (1287lX1280-12)

combinations after every cross. Also, many potato plants have infertile flowers, making crossbreeding impossible.

The scientific underpinning of today's potato breeding has been developed at Webb's laboratory at the Beltsville Agricultural Research Center in Maryland. He calls the Beltsville work planned parenthood for potatoes.

After he searches scientific literature of the past 50 years for mentions of plants with desirable traits, Webb uses as many as 300 parents from seed banks such as the ARS Inter-Regional Potato Introduction Station at Sturgeon Bay, Wisconsin.

Tiny, (60,000 per ounce) true potato seeds are the first results of crosses Webb makes. Following a year's dormancy, these seeds are planted in greenhouses. Seedlings are grown from August to December instead of during the normal Maryland potato-growing season of May to September. The season shift is to avoid infecting young plants with potato viruses transmitted by airborne aphids during the regular growing season.

Webb harvests nickel-size seedling tubers in December. From these, he selects only long russets with potential for eastern growers. Each year, he sends about 30,000 greenhouse-grown minitubers to cooperating breeders across the country. Webb personally takes another 40,000 to a remote farm in Maine where they begin several years of testing.

The 57-acre Chapman farm is operated by ARS under strict quarantine conditions. Chapman lies at least two miles, as the potato aphid flies, from any other potato field in Aroostook County—the seed potato capital of the eastern United States. Most grower's seed is grown in northern areas where a 3- to 4-foot-deep frost kills off diseases. Webb and farm manager David Wilson, an ARS horticulturist, proudly maintain that Chapman is "as fine a potato farm as any." It does have the distinction that potatoes are planted and harvested by hand to prevent any possible disease spread. Even knives used to cut potatoes into seed pieces are flame-sterilized between each cut.

Year after year, the 40,000 or so tubers from Beltsville are winnowed until fewer than 50 finalists remain. During September and October each year, state breeders join Webb at Chapman and on the nearby Maine Agricultural Experiment Station to cull these finalists for potatoes good enough to become new varieties. But few make it.

Take September 8th, last fall: Webb leads Wilson, a group of state scientists, and ARS plant pathologist Robert Goth through a 100-foot plot of the 46 finalists of 1987. Each experimental potato is piled where it grew and marked with a 4-digit number on a wooden stake.

Webb scans potatoes with one eye while the other checks his data book. Wilson follows with an identical book, noting Webb's comments. He kicks over stakes of numbers Webb chooses to discard. "3533 is a good processor, Dave, yes good yield again this year. Shows good solids. Keep it. Now, Dave, here is a russet that will grow from here to Florida if people are willing to try it. Keep it." And so it goes.

"He is the best potato breeder alive today," says Goth, walking beside Webb checking for disease symptoms. Of the 46 stakes, 13 remain upright. Those potatoes will be grown in cooperating states for another 3 or 4 years.

Says Florida's Schumaker, "The thing about our program is that each breeder is looking for different traits. I need resistance to brown rot that occurs in Florida but not in states to the north. I work with Webb to make sure that resistance is built into new varieties."

In 1988, the states will test yellow-flesh potatoes and disease-resistant red

Potatoes

types bred to strengthen U.S. potato seed exports to Central and South America and Africa. "Those markets are now supplied from Europe," says Webb.

"The program's 1987 release was Coastal Russet, a disease-resistant variety of baking potato that will allow farmers to use less pesticide.

Wilson says that many of the finalists not chosen are saved. Having passed all but the final tests, they have genes that breeders will need again.

Webb says, "We do have a complex testing system, but we have barely touched on the genes available. There are more than 5,000 varieties of potato known, but only 6 make up 80 percent of the U.S. potato crop.

"Ray Webb has helped Maine, Florida, North Carolina, Rhode Island, Virginia, Pennsylvania, Delaware, and other states to build up good testing programs," says Stanley P. Greaves, associate director of the Maine Potato Seed Board. "But we still need potatoes with tougher skins, that resist hot weather, not to mention pests that have become resistant to pesticides. Since it takes up to 15 years for a new potato to meet standards of science, farm, market, and consumers, Webb's 17-year program is just coming of age, with the best yet to come."—By **Stephen Berberich,** ARS.

Raymon E. Webb is in the USDA-ARS Vegetable Laboratory, Bldg. 004, Beltsville Agricultural Research Center-West, Beltsville, MD 20705. ♦

Soil Yields 72 New Varieties of a Natural Pest Control

Soil from the Himalayan mountains, from a car bumper in Iceland, or even from the bottom of a cat's foot could mean death to insect pests.

In soil from these and other places—almost always brought by vacationing friends—U.S. Department of Agriculture scientists have found 72 new varieties of a soil bacterium, *Bacillus thuringiensis* (Bt)—a natural control for insect pests.

Three varieties, two from beside an airport in Baltimore, Maryland, and one from the Snake River in Jackson, Wyoming, await patents. In a field trial, they were as effective as the best available chemicals at killing cabbage loopers and worms, says Phyllis A.W. Martin, a geneticist with USDA's Agricultural Research Service in Beltsville, Maryland.

Bt kills insects by rupturing their stomach cells, making them unable to feed and digest food. "There might still be live caterpillars on a crop, but they can't do much damage if they can't feed," Martin says. And eventually, the insect larvae will die.

"Scientists have been hunting for this kind of control from Bt for about 25 years," says Russell S. Travers, formerly an ARS researcher working with Martin and now with Novo Laboratories, Wilton, Connecticut. He believes that the new varieties are 10 times as effective as present commercial Bt strains and could replace them in an industry worth about $40 million a year worldwide.

The fact that Martin and Travers derived all of their new Bt from soil may change Bt history. "Previously, scientists thought that to get the bacterium you had to find a dead insect; we just assumed it was an insect disease," Travers says. "But our studies indicate that Bt is really a normal component of many soils."

In fact, nearly 4 miles above sea level, where there's almost no insect life, the scientists found Bt's that kill caterpillars, mosquitoes, and beetles.

"We're sure that the fact that Bt kills insects is just plain luck," Martin says, "since we're finding that killing insects is not its usual role in nature."

The "luck" first benefited farmers in 1970, when a variety of Bt called HD1, developed by Howard Dulmage at an ARS laboratory in Brownsville, Texas, went commercial to kill caterpillar pests.

TIM McCABE

ARS geneticist Phyllis Martin and entomologist Russell Travers expose a variety of new Bt strains to sunlight to weigh the effects of sunlight on the strain's toxicity under outdoor conditions. (0787X768-23)

Martin and Travers pioneered the techniques that allowed them to find and grow their new strains in the lab.

"The 24 varieties already known took about 85 years to find; with this new technique, we were able to identify 72 more in just 2 years," Travers says. "We got the technique for isolating Bt from soil through a chance recollection of mine."

He had, for his dissertation in graduate school, been looking for something to help Bt go from the dormant spore stage to an infective stage. One of the chemicals that didn't work was sodium acetate. "In fact, everything but Bt would germinate. The acetate actually keeps it dormant," he says.

So 4 years later, when Travers and Martin were discussing how they might isolate Bt from the soil, Travers suddenly remembered this "failure."

When they put soil in acetate, the "background" organisms all germinated; the scientists killed these with heat. "Then we waited for whatever was left to germinate, and we found Bt—lots of

TIM McCABE

Phyllis Martin sprays a new Bt solution on tomato plants in studies to determine its toxicity to the Colorado potato beetle. (0787X770-21)

it," Martin says.

The Bt from the cat's paw, which kills mosquitoes in laboratory tests but hasn't been tested in the field, came to the lab by accident.

"A scientist from a different lab walked in one day and said, 'Your lab always smells like my cat Fluffie's feet.' So, almost as a joke, we gave her a petri dish and told her to take it home and imprint Fluffie's paw on it," Martin says.

Test results: yet another variety, one of the 72, dubbed *Bacillus thuringiensis* var. *fluffiensis*. "She got it from her clay kitty litter," Travers says.

But the similar odor was from the Bt itself. "It has a very distinctive odor, like wet dog fur or fermented grain," he says.

The Bt-containing soil from the car bumper in Iceland and from the Himalayas was brought by an adventurous friend, an ARS scientist, who likes mountain climbing. "He's never forgiven us for making him collect and carry jars full of soil at almost 19,000 feet," Martin says.

After exploring Nutt Cave in West Virginia, the friend scraped cave soil off his dirty clothes for Travers and Martin. In it, they found two new varieties and named them Bt var. *nutti* and Bt var. *cavi* after their origin. "When you get up around 72 varieties, you start to get a little fanciful with names," Travers says.

The scientists aren't ready to test most of the new varieties in the field. For now, Martin says, "we're trying to find out exactly what makes a Bt 'hot' and from those indicators, we'll know which of the new varieties warrant field tests."—By **Jessica Morrison,** ARS.

Phyllis A.W. Martin is in the USDA-ARS Insect Pathology Laboratory, Bldg. 011A, Beltsville Agricultural Research Center-West, Beltsville, MD 20705. ♦

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PATENTS

A Vaccine for Swine Trichinosis

The nematode worm *Trichinella spiralis* costs the pork industry more than $400 million per year in lost sales and control measures. Now a vaccine has been developed to prevent pigs from picking up this muscle-invading parasite that causes trichinosis.

Several vaccines against trichinosis have been produced in recent years, but the immunity rate they afforded was low. The new vaccine developed by Agricultural Research Service scientists promises a higher degree of immunity than has ever before been possible.

Previous vaccines were derived from extracts of adult Trichinella; the new vaccine comes from killed larvae. It induces up to 88 percent immunity.

This new treatment offers farmers a practical, effective measure to prevent transmission of trichinosis.

For technical information, contact Kenneth D. Murrell, USDA-ARS Beltsville Agricultural Research Center, Bldg. 003, Room 227, BARC-West, Beltsville, MD 20705. Patent Application Serial No. 07/068,499, *"Vaccine for Swine Trichinosis."*

A Fungal Foe for Jimsonweed

Jimsonweed is a notorious weed native to the eastern half of the United States. Not only does it compete with soybeans and cotton, but its foliage and seeds contain alkaloids that can harm livestock and humans. Many of today's herbicides don't work well on jimsonweed; once it matures, it stubbornly resists control. However, a fungus, *Alternaria crassa,* has been found to be pathogenic to jimsonweed but essentially harmless to crops.

Patent-applied-for methods to intentionally spread this weed-walloping fungus may save thousands of dollars in wasted herbicides. The fungus, in the form of dormant spores, is broadcast on vegetation, where it will selectively destroy jimsonweed. Several means of application are possible: water-based and oil-based liquid sprays, granules, and gel pellets.

Not only is the fungus safe for soybeans and cotton, researchers were able to verify that *A. crassa* does little harm to most garden plants. Out of seven families of crops, only one variety of tomato died after being exposed to the fungus.

For technical information, contact Clyde D. Boyette, USDA-ARS Delta States Research Center, P.O. Box 350, Stoneville, MS 38776. Patent Application Serial No. 07/092,100, *"Control of Jimsonweed."*

Soil Yields New Varieties of Bt

See page 14 for information on Patent Application Serial No. 07/050,450, *"Acetate Selected* Bacillus Thuringiensis *and the Method of Use."*

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